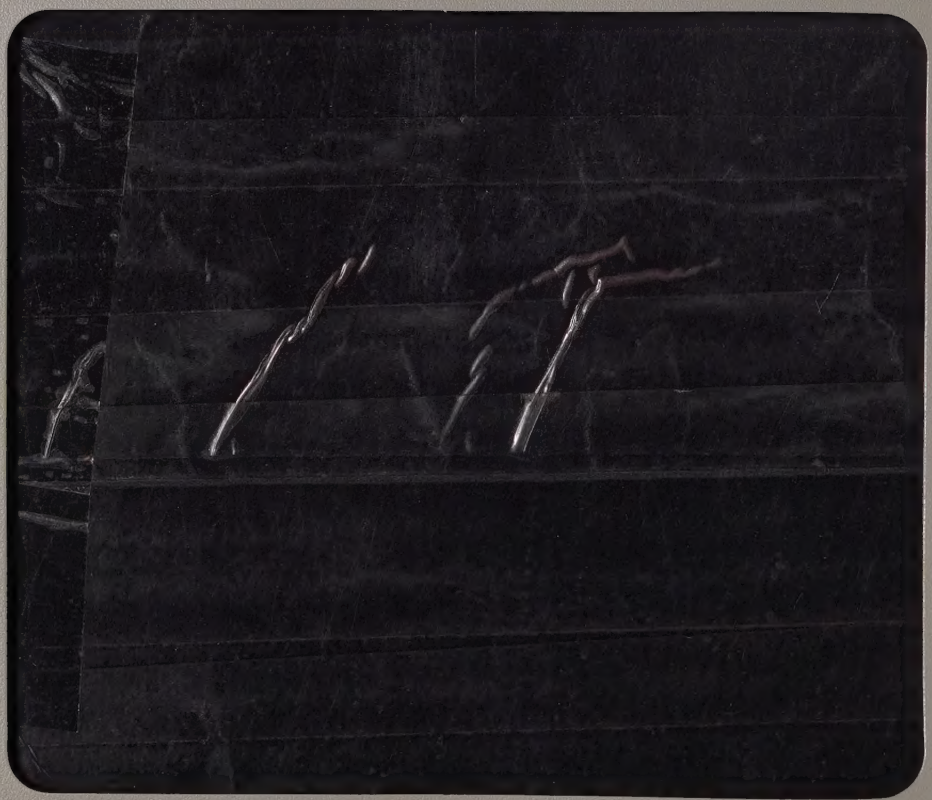
FT-50010

TURBINE ELECTRICAL SYSTEM TEST SET

Operator Manual

FLUKE®



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TURBINE ELECTRICAL SYSTEM TEST SET

Operator Manual

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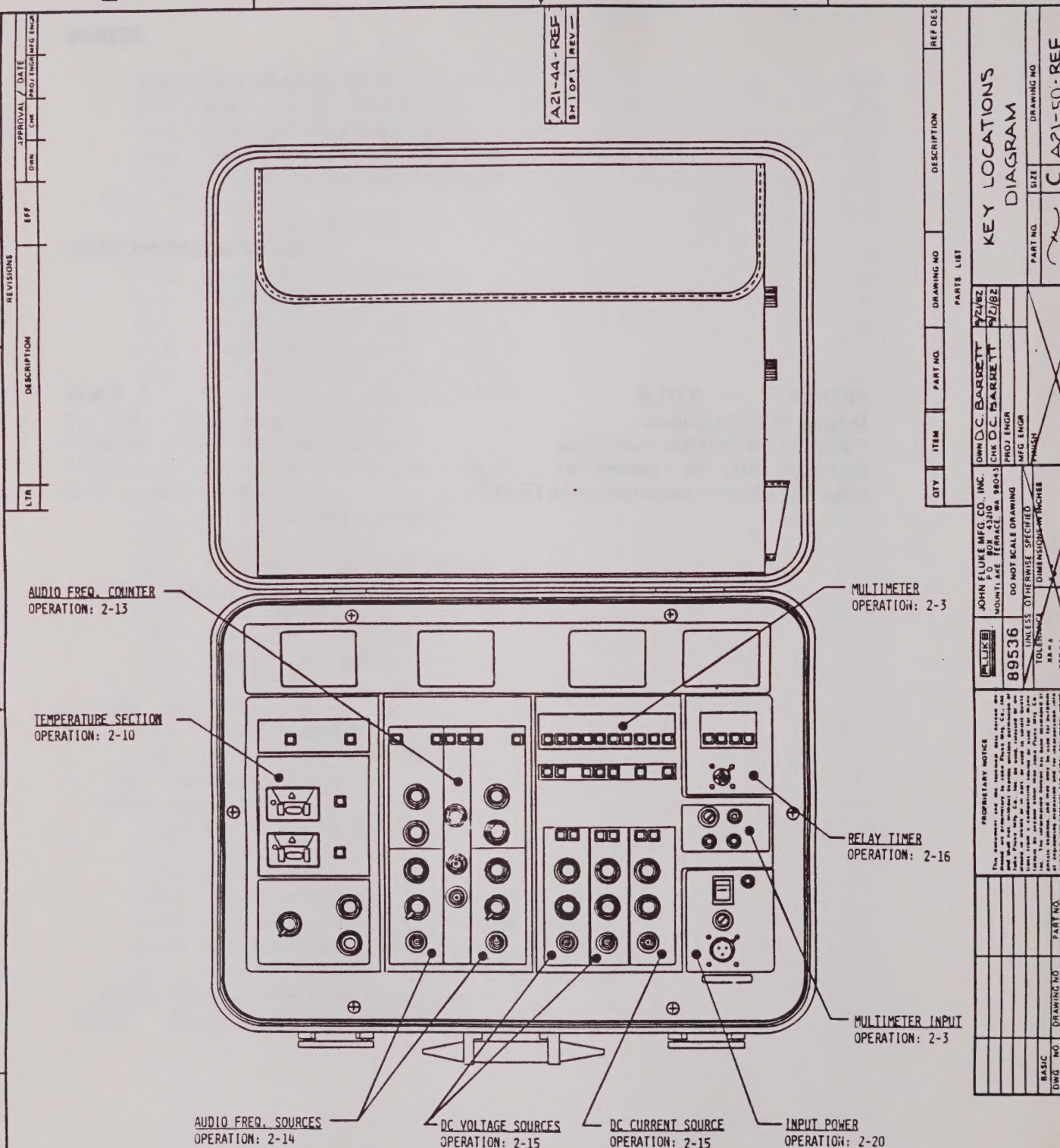

NOTES:

1. INTRODUCTION TO INSTRUMENT: 1-1
2. KEY LOCATIONS REFERENCED BY SECTION/PAGE NUMBER.

SECTION 1
INTRODUCTION AND SPECIFICATIONS

1-1. INTRODUCTION

1-2. The FT50010 is a portable, integrated test set designed specifically for field testing and trouble shooting of turbine electrical and control systems. It consists of a digital thermometer, a thermocouple indicator calibration source, a digital frequency counter, two audio function generators, two dc voltage sources, a dc current source, a digital multimeter, and a digital time delay relay calibrator. The entire package is housed in a rugged aluminum suitcase and operates from a single dc power source of between 20 and 34 volts.

1-3. All the functions can operate simultaneously without switching hookup leads thus significantly reducing the number of leads necessary and time required to perform maintenance tasks.

1-4. The FT50010 test set can be used to simulate engine sensory inputs to a turbine control system. The FT50010 test set then can start, operate, and shut down the control system in a static calibration mode or perform a verification function in an engine operational mode.

1-5. Temperature Section

1-6. The thermometer section of the FT50010 is a microprocessor based thermocouple indicator capable of precise temperature measurement in either °C or °F.

1-7. Eight switch selectable linearization programs provide a total measurement range of -252°C to 2471°C. Resolution is 0.1° below 2000° and 1° at 2000° and above. (Refer to Table 1-1 for range and accuracy information for each thermocouple type.)

1-8. Electronic cold junction compensation is provided at each of two isolated thermocouple inputs, eliminating the need for external ice point reference baths.

1-9. The thermocouple calibration source simulates any of the eight thermocouple types available on the FT50010 thermometer section. This section operates together with the thermometer to provide a convenient means of accurately calibrating external indicators.

1-10. Audio Frequency Section

1-11. The frequency counter section accurately measures sine or square wave inputs over a frequency range of 25 Hz to 100 kHz with 1 Hz resolution. This section also features adjustable input sensitivity and automatic frequency overrange indication.

1-12. The two frequency sources are identical and provide sine and square wave functions over a frequency range of 25 Hz to 15 kHz. Output amplitude is adjustable from 0 to 20V rms into a maximum load of 600Ω, with outputs protected against accidental overloads or short circuiting. An adjustable dc offset of 0 to ±18 volts is also provided.

1-13. Multimeter Section

1-14. This section of the FT50010 is a 3-1/2 digit multimeter capable of measuring dc to 1000 volts and 2000 mA, true rms ac to 750V and 2000 mA, resistance to 20 MΩ, and conductance to 2 mS (millisiemens).

1-15. Multimeter input select switches are also provided allowing the operator to select any of the internal sources, either of two external frequency inputs, or any external voltage, current, or resistance.

1-16. DC Voltage/Current Section

1-17. The two voltage sources are identical and provide 0 to 10V dc on two ranges. Maximum load current is 400 mA, with output protected against accidental overloads or short circuiting. Source impedance to the output connector is less than 0.04Ω.

1-18. The current source provides 0 to 100 mA on two ranges. Maximum compliance voltage is +28V dc.

1-19. Timer Section

1-20. The relay timer section of the FT50010 permits checkout and accurate setting of all time delay relays, for either solid state or pneumatic delays. Both pick up and drop-out mode timing are provided. The relay timer is capable of measuring relay contact time delays up to 1999.9 seconds.

1-21. Power Supply

1-22. Power input conditioning is provided by a single switching mode preregulator. This section supplies a regulated 12 volts dc to each of four driven inverters. The four inverters provide a total of 8 isolated supplies to the various functional subsections.

1-23. SPECIFICATIONS

1-24. Specifications for the FT50010 are shown in Table 1-1.

Table 1-1. FT50010 Specifications

Thermocouple Thermometer

DISPLAY	°F or °C, switch selectable, seven segment liquid crystal
RESOLUTION	0.1° below 2000°F or °C, 1° above 2000°F or °C, autoranging
MEASUREMENT METHOD	Dual slope integration, under microcomputer control. 100 ms integration period, three readings per second
LINEARIZATION TECHNIQUE	Computer algorithm, 4th order curve fit. Eight switch selectable linearizations: J, K, T, E, R, S, B, C

NOTE: "C" is not an ISA/ANSI thermocouple designation. C is used for convenience to represent Tungsten 5% Rhenium versus Tungsten 26% Rhenium alloy.

TEMPERATURE COEFFICIENT	≤15 ppm/°C from 25°C
STABILITY	≤175 ppm in 90 days, 200 ppm/year
MAX. COMMON MODE VOLTAGE	350V dc or 250V ac rms
ZERO DRIFT	None, automatic zero correction
INPUT CONNECTION	2 wire, isolated, on screw terminal isothermal block. Two switch selectable inputs
INPUT IMPEDANCE	100 MΩ at dc
MAX SOURCE IMPEDANCE	2 kΩ
OVERRANGE INDICATION	Positive or negative full scale display (± O.L), depending upon polarity of overrange input
OPEN CIRCUIT DETECTION	A source impedance of 2 kΩ or more causes a display of "0.C"
ACCURACY	See adjacent table "Thermometer Accuracy Specifications"

THERMOMETER ACCURACY SPECIFICATIONS

T/C TYPE	MAXIMUM ERROR *							
	±°C				±°F			
	APPLICABLE PORTION OF TEMP. RANGE, °C	AT CAL.	90 DAYS 20°C TO 30°C	1 YEAR 15°C TO 35°C	APPLICABLE PORTION OF TEMP. RANGE, °F	AT CAL.	90 DAYS 68°F TO 86°F	1 YEAR 59°F TO 95°F
J	-128 to 0 0 to 900	0.18 0.18	0.19 0.31	0.21 0.36	-198 to 32 32 to 1652	0.20 0.20	0.23 0.47	0.26 0.58
K	-132 to 0 0 to 1350	0.18 0.18	0.19 0.39	0.21 0.47	-206 to 32 32 to 2462	0.30 0.30	0.33 0.72	0.37 0.87
T	-243 to 0 0 to 400	0.18 0.18	0.20 0.22	0.22 0.25	-405 to 32 32 to 752	0.30 0.30	0.35 0.41	0.39 0.46
E	-252 to 0 0 to 1000	0.18 0.18	0.20 0.33	0.22 0.39	-422 to 32 32 to 1832	0.30 0.30	0.35 0.61	0.40 0.72
R	0 to 1708	0.31	0.59	0.70	32 to 3106	0.47	1.01	1.20
S	0 to 1685	0.22	0.50	0.60	32 to 3065	0.38	0.92	1.10
B	420 to 1815	0.21	0.52	0.62	788 to 3364	0.37	0.95	1.15
C	0 to 2471	0.18	0.60	0.75	32 to 4480	0.30	1.11	1.37

* For readings above 1999.9 °C or °F add ±0.5° round off error. Accuracy specifications do not include thermocouple sensor or wire errors.

Table 1-1. FT50010 Specifications (continued)

Thermocouple Calibrator

COMPATIBLE THERMOCOUPLE TYPES.....	J, K, T, E, R, S, B, C
OUTPUT IMPEDANCE.....	100Ω
RANGE.....	-10 to +90 mV dc, 25°C
TEMPERATURE COEFFICIENT.....	≤ 20 ppm/°C from 25°C

Audio Frequency Counter

MEASUREMENT RANGE.....	25 Hz to 100 kHz
DISPLAY.....	5-digit liquid crystal with 'Hz'
ACCURACY.....	±(0.01% + 1 count) 0 - 50°C
TIMEBASE STABILITY.....	≤ 10 ppm/year
GATE TIME.....	1 second
DISPLAY UPDATE TIME.....	1.2 second
SENSITIVITY.....	Adjustable 75 mV rms to full scale, over 25 Hz to 100 kHz
MAXIMUM INPUT WITHOUT DAMAGE....	500V dc or peak ac
INPUT IMPEDANCE.....	10 MΩ for inputs -1 to +1 volt 100 kΩ for inputs above ±1 volt
OVERFLOW.....	Display reads 0.0.0.0.0

Audio Frequency Sources

FUNCTION.....	Sine, Square; switch selectable
FREQUENCY RANGE.....	25 Hz to 15 kHz
FREQUENCY TEMP COEF.....	≤ 0.5%/°C
AMPLITUDE.....	0 to 20V rms into 600Ω
DISTORTION (SINE WAVE).....	5% from 1 kHz to 10 kHz
OUTPUT IMPEDANCE.....	Less than 1Ω
DC OFFSET.....	-18V to +18V variable

Table 1-1. FT50010 Specifications (continued)

Multimeter

DISPLAY..... 3-1/2 digit liquid crystal, auto polarity and decimal point

DC VOLTS (Multimeter)

Accuracy, 1 Year..... ±(0.1% of reading + 1 digit)

Input Impedance..... 10 MΩ

Overvoltage Protection..... 1000V dc or peak ac

Response Time..... 1 second

AC VOLTS (Multimeter)

Accuracy, 1 Year..... see table below

Crest Factor Range..... 1.0 to 3.0

Input Impedance..... 10 MΩ/100 pf

Overload Protection..... 750V rms or 1000V peak

Not to exceed the volt-hertz product of 10^7 (except for 10 seconds maximum on 200 mV & 2V range)

Response Time..... 2 seconds maximum within a range

AC Voltage Accuracy

<table>
<tr><th>RANGE</th><th>45 Hz TO 1 kHz</th><th>1 kHz to 10 kHz</th><th>10 kHz to 20 kHz</th></tr>
<tr><td>200 mV</td><td rowspan="4" colspan="2">±(0.8% of READING + 2 DIGITS)</td><td rowspan="3">±(1% of READING + 2 DIGITS)</td></tr>
<tr><td>2V</td></tr>
<tr><td>20V</td></tr>
<tr><td>200V</td></tr>
<tr><td>750V</td><td colspan="2">NOT RATED</td></tr>
</table>

Table 1-1. FT50010 Specifications (continued)

DC CURRENT (Multimeter)

Accuracy..... ±(0.3% of reading + 1 digit)

Burden Voltage..... 0.3V max, 200 µA thru 200 mA ranges; 1.5V max, 2000 mA range

Overload Protection..... 2A/250V external fuse in series with an internal 3A/600V fuse

AC CURRENT (Multimeter)

Accuracy, 1 Year..... see table below

Burden Voltage..... 0.3V max, 200 µA to 200 mA ranges; 1.5V max, 2000 mA range

Overload Protection..... 2A/250V external fuse in series with an internal 3A/600V fuse

Crest Factor Range..... 1.0 to 3.0

Response Time..... 2 seconds maximum within a range

AC Current Accuracy

<table>
<tr><th>RANGE</th><th>45 Hz to 2 kHz</th><th>2 kHz to 10 kHz</th><th>10 kHz to 20 kHz</th></tr>
<tr><td>200 µA</td><td rowspan="4" colspan="2">±(1% of READING + 2 DIGITS)</td><td rowspan="4">±(2% of READING + 2 DIGITS)</td></tr>
<tr><td>2 mA</td></tr>
<tr><td>20 mA</td></tr>
<tr><td>200 mA</td></tr>
<tr><td>2000 mA</td><td colspan="2">NOT RATED</td></tr>
</table>

Table 1-1. FT50010 Specifications (continued)

RESISTANCE (Multimeter)

Accuracy, 1 Year..... see table below

Overload Protection..... 300V dc/ac rms, all ranges

Open Circuit Voltage..... less than 3.5V, all ranges

Response Time..... 1 second, 200Ω thru 20 kΩ ranges
4 seconds, 200 kΩ and 20 MΩ ranges

Resistance Accuracy

RANGE	ACCURACY	FULL SCALE VOLTAGE	MAX TEST CURRENT
200Ω*	±(0.2% of READING + 1 DIGIT)	0.025V	1.3 mA
2 kΩ		1.0V	1.3 mA
20 kΩ		< 0.25V	10 µA
200 kΩ		1.0V	35 µA
2000kΩ	±(0.5% of READING + 1 DIGIT)	< 0.25V	0.10 µA
20 MΩ		1.5V	0.35 µA

*For specified accuracy in the 200Ω range, any residual resistance must be zeroed: record the measurement, then subtract from that the reading obtained with the input leads shorted together.

Table 1-1. FT50010 Specifications (continued)

CONDUCTANCE (Multimeter)

Accuracy, 1 Year..... see table below

Overload Protection..... 300V dc/ac rms on all ranges

Conductance Accuracy

RANGE	ACCURACY	FULL SCALE VOLTAGE	MAX TEXT CURRENT
2 mS	±(0.2% of READING + 1 DIGIT)	3.5V	1.3 mA
20 µS		1V	10.0 µA
200 nS	±(1% of READING + 10 DIGITS)	1V	0.10 µA

DC Voltage Sources

OUTPUT..... 2 Ranges; 0 to 1V, 0 to 10V

OUTPUT IMPEDANCE..... < 0.040Ω to the output connector

TEMPERATURE COEFFICIENT..... ≤ (20 µV + 250 ppm)/°C

MAX. LOAD CURRENT..... 400 mA

OUTPUT PROTECTION..... Protected against continuous short circuit

CURRENT LIMIT POINT..... ~ 600 mA

DC Current Source

OUTPUT..... 2 Ranges; 0 to 1000 µA, 0 to 100 mA

TEMPERATURE COEFFICIENT..... ≤ 200 ppm/°C

COMPLIANCE VOLTAGE..... +28V max

Table 1-1. FT50010 Specifications (continued)

Relay Timer

RANGE	1999.9 seconds
MODES	Delay pick up, delay drop out
DISPLAY	4-1/2 digit liquid crystal with decimal point
ACCURACY	±0.01% + 1 count, 0 to 50°C
TEMPERATURE COEFFICIENT	≤ 0.1 ppm/°C
TIMEBASE STABILITY	≤ 10 ppm/year
OVERFLOW	Display reads 0.0.0.0.0

General Specifications

POWER	20 to 34V dc, 3A max
WARM UP TIME	5 minutes
DIMENSIONS	15.4 cm H x 33.0 cm W x 45.7 cm L (6.08" H x 13" W x 18" L)
WEIGHT	Approximately 8.6 kg, (19 lbs)

Environmental

STORAGE TEMPERATURE	-40°C to 75°C
OPERATING TEMPERATURE	0 to 50°C
RELATIVE HUMIDITY	0 to 80% up to 50°C (non-condensing)
SHOCK AND VIBRATION	Meets MIL-T-2800 Specifications

SECTION 2
OPERATING INSTRUCTIONS

2-1. INTRODUCTION

2-2. The FT50010 operator panel is arranged into the functional subsections: multimeter, thermometer, audio frequency sources, dc voltage sources, dc current source, and relay timer. Four displays allow for simultaneous measurement of thermometer, frequency counter, multimeter, and relay timer. Adjustments or measurements made on one section will have no effect on any of the other sections.

2-3. The following paragraphs describe operation of each of these sections. The multimeter is covered first as this section is used to monitor most of the other sections.

> NOTE: Instructions for making power input connections are covered in paragraphs at the end of Section 2, under Making Power Connections.

2-4. There are five triangular shaped caution ⚠ symbols located on the instrument front panel. One on each of the two thermocouple input assemblies, one next to the T/C signal select pushbutton, one next to the external frequency input jacks, and one on the multimeter input jacks. Please refer to the four cautions in later sections of this manual marked by these same symbols.

WARNING

DO NOT TOUCH TERMINALS WHEN HIGH VOLTAGES ARE PRESENT. ALL SECTIONS OF THE FT50010 AND ASSOCIATED INPUTS AND OUTPUTS ARE ELECTRICALLY ISOLATED FROM EACH OTHER. UP TO 350V DC OR PEAK AC MAY BE PRESENT BETWEEN TERMINALS IN DIFFERENT SECTIONS OR BETWEEN ANY TERMINAL AND THE INSTRUMENT CASE.

2-5. SHIPPING INFORMATION

2-6. The FT50010 Test Set is packaged and shipped in a foam-packed container. Upon receipt of the instrument, a thorough inspection should be made to reveal any possible shipping damage. Special instructions for inspection and claims are included in the shipping carton.

2-7. If reshipment of the instrument is necessary, the original container should be used. If the original container is not available, a new container can be obtained from the John Fluke Mfg. Co., Inc. Please reference the instrument's model number when requesting a new shipping container.

2-8. OPERATING NOTES

2-9. Multimeter Section

2-10. MULTIMETER DISPLAY

2-11. The multimeter display is a 3-1/2 digit LCD providing 1,999 counts of resolution. A decimal point, polarity indicator, and overrange indicator are also included. Decimal point positioning is automatic and is determined by the selected measurement range.

2-12. Polarity sensing is also automatic, and is valid for dc voltage and current measurements. A minus sign indicates that the input voltage or current is negative with respect to multimeter input common. Voltage or current inputs that are positive with respect to common are indicated by the absence of a minus sign.

> NOTE: Two other conditions may cause the negative sign to be displayed, neither of which indicates a valid display. Please refer to paragraphs 2-13 (Overrange) and 2-43 (Resistance).

2-13. OVERRANGE

2-14. An overrange condition is indicated by a "1" followed by three blank digits. (A decimal point may also be present, depending upon the range selected.) An overrange display indicates that the unknown input (voltage, current, resistance, or conductance) is of sufficient amplitude to require that a higher range be selected, and does not necessarily mean that the input will damage the instrument. (Refer to multimeter specifications, Table 1-1, for dc volts or ac volts overvoltage limits.)

2-15. When measuring resistance, the overrange indication is displayed to indicate an open input condition or an input resistance greater than the selected range can measure.

> NOTE: When the instrument comes out of an overrange condition the minus sign may flash momentarily (most likely seen when measuring resistance).

2-16. MEASUREMENT UNITS

2-17. There are no measurement unit indicators on the multimeter display. To determine units of measure note the selected function and range. For example if the volt (V) function is selected, and the 200 mV range is selected, and the unknown input is within the selected range; the display will represent a voltage of between 000.0 and ±199.9 mV.

2-18. FUNCTION SWITCHES

2-19. The first four pushbutton switches on the left, directly below the multimeter display, are used to select the desired measurement function.

2-20. The leftmost switch, marked AC/DC, is used in conjunction with the "V" and "mA" switches to determine the type of voltage or current to be measured. If the AC/DC switch is in the OUT position the multimeter is configured for DC voltage or current measurement. If the switch is depressed, only the AC components of the input signal will be measured.

2-21. The V, mA, and kΩ/S switches select the voltage, current or resistance/conductance functions. These three pushbuttons are interlocked. Depressing one pushbutton will cause either of the other two to return to the out position.

2-22. RANGE SWITCHES

2-23. The next six pushbuttons are used to select the desired measurement range. They provide 5 ranges of AC/DC voltage and current, 6 ranges of resistance, and three ranges of conductance. They are also interlocked. As indicated on the operator panel, any one of the three conductance ranges may be selected by depressing the two appropriate pushbuttons simultaneously.

2-24. MULTIMETER INPUT SELECT SWITCHES

2-25. The EXT/INT pushbutton is used to connect either the multimeter external input terminals or the internal select switches to the multimeter input. The EXT/INT pushbutton must be in the OUT position to connect the FREQ, EXT FREQ, DC VOLTS OUT, or DC mA OUT to the multimeter.

2-26. Directly below the function and range switches there is a group of seven pushbutton switches. These switches are used to select the desired input to the multimeter.

2-27. The pushbuttons marked FREQ 1 and 2 connect the outputs of the internal frequency sources to the multimeter input. Both waveform amplitude and dc offset level can be measured by proper multimeter function selection.

2-28. The EXT FREQ pushbutton is used to connect the selected external frequency input to the multimeter input.

2-29. The DC VOLTS OUT 1 and 2 pushbuttons are used to connect either one of the two internal dc voltage source outputs to the multimeter input.

> NOTE: The regulation specifications given in Section 1 for the DC Voltage Sources apply to voltage levels present at the output terminals, which is where multimeter measurements are made. If greater measurement accuracy is required (as may be the case if output current is near the maximum specified and the test leads to the load are long) it is suggested that the voltage measurements be made at the load using the multimeter external input.

2-30. The DC mA OUT pushbutton is used to connect the output of the current source to the multimeter mA input. When this switch is depressed the multimeter is placed in series with the internal compliance voltage source and the current source output high terminal. If DC mA OUT is NOT selected the internal compliance voltage source is connected directly to the current source output high terminal.

NOTE: In order for current to flow, a load must be placed between the current source HI and LO output terminals.

2-31. The EXT/INT pushbutton is used to connect either the multimeter external input terminals or the internal select switches to the multimeter input. With the EXT/INT pushbutton pushed in the multimeter may be used to measure any external voltage, current, or resistance source that does not exceed specified input limits.

2-32. MULTIMETER EXTERNAL INPUT

2-33. This section consists of three banana/binding post connectors and a fuse. Voltage, resistance, and conductance inputs are connected between the V/kΩ/S and common terminals. Current inputs are connected between the mA and common terminals. The fuse is to protect the current input circuitry from damage if a current input of greater than 2A is applied.

2-34. VOLTAGE MEASUREMENTS

2-35. To make voltage measurements, use the following procedure:

CAUTION

THE VOLTAGE SOURCE SHOULD NOT EXCEED 1000V DC OR 750V RMS AC OR DAMAGE TO THE INSTRUMENT MAY RESULT.

1. Select the AC or DC volts function.
2. Select the desired measurement range.
3. Select the desired voltage source (any of the internal sources, or the external binding posts).
4. The unknown voltage should now be displayed.

2-36. Under most measurement conditions, source loading errors should not be a problem. If source impedance is 10 kΩ or less, the error will be less than 0.1%. Loading error can be calculated using the formulas listed below.

1. For DC voltage measurements:

$$\text{Error in \%} = 100 \times R_S \pm (R_S + 10^7)$$

Where: R_S = source resistance in ohms (Ω)

2. For AC voltage measurements:

$$\text{Error in \%} = \frac{100 \times Z_S}{R_S + Z_{IN}}$$

Where: R_S = Source Resistance
Z_S = Source Impedance
Z_{IN} = Effective Input Impedance; where:

$$Z_{IN} = \frac{10^7}{\sqrt{1 + (2 \times \pi \times F \times R_{IN} \times C)^2}}$$

Where: $R_{IN} = 10^7\Omega$
$C = 100 \times 10^{-12}F$
F = Hz
$\pi = 3.14159$

2-37. Composite AC/DC waveforms can also be measured. Measure the ac component of the waveform using the AC function of the multimeter. Measure the dc component using the DC function. The total rms value of the waveform is:

$$\text{RMS Total} = \sqrt{(\text{AC Component})^2 + (\text{DC Component})^2}$$

2-38. CURRENT MEASUREMENTS

2-39. To make current measurements, use the following procedure:

CAUTION

INPUT CURRENT SHOULD NOT EXCEED 2A. OPEN CIRCUIT VOLTAGE SHOULD NOT EXCEED 250V DC or 250V PEAK AC.

1. Select AC or DC current function.
2. Select desired measurement range.
3. Connect the multimeter into the circuit to be tested. The unknown current should now be displayed.

2-40. If the current source being measured is unregulated, or if the resistance of the multimeter current shunt and fuse represents a significant part (1/1000 or more) of the source resistance, then burden voltage errors may need to be considered. Burden voltage is the voltage drop at the multimeter's terminals when measuring current (that voltage across the multimeter's current shunt and protective fuses).

2-41. Burden voltage error can be calculated using the following formulas:

$$E_B = \frac{100 \times \text{Reading} \times E_{B_{(\text{Full Scale})}}}{\text{Full Scale}}$$

Where: Reading = Displayed Current Reading
E_B = Burden voltage (calculated)
Full Scale = Range Selected
$E_{B_{(\text{Full Scale})}}$ = Specified full scale burden voltage for range selected (Refer to multimeter DC or AC Current specifications for this value).

$$\% \text{ error} = 100 \times \frac{E_B}{E_S - E_B}$$

Where: E_B = Burden Voltage (Calculated)
E_S = Source Voltage

$$\text{Error in amps} = \frac{E_B}{E_S - E_B} \times I_M$$

Where: E_B = Burden voltage (calculated)
E_S = Source voltage
I_M = Measured current in amps

2-42. An example of burden voltage calculations follows. Assume these conditions are given: E_S = 14V, R_L = 9Ω, I_M = 1.497A, $E_{B(Full\ Scale)}$ (from specification table) = 1.5V

1. $$E_B = \frac{1.497A}{2.000A} \times 1.5V$$

$$= 74.85\% \text{ of } 1.5V$$

$$= 1.123V$$

2. $$\% \text{ Error} = 100 \times \frac{1.123}{14 - 1.123}$$

$$= 8.721\%$$

3. $$\text{Error in amps} = \frac{1.123}{14 - 1.123} \times 1.497$$

$$= 0.131A$$

Displayed Current = 1.497A
Actual Current = 1.628A

2-43. RESISTANCE MEASUREMENTS

2-44. To make resistance measurements, use the following procedure:

1. Select the Resistance function.
2. Select the desired measurement range. The multimeter should display an open circuit condition ("1" followed by three blank digits), with no load connected.
3. Connect the unknown resistance to the multimeter external input.
4. The unknown resistance should be displayed.

2-45. When using the 200Ω range, more accurate measurements can be made if lead resistance is considered. Short the sampling ends of the test leads together and read the lead resistance and subtract this lead resistance from your measurements.

2-46. The 2 kΩ resistance range has a diode symbol beside the range value and has a high enough open circuit voltage to turn on silicon junctions. This range can be used to check silicon diodes and transistors. In circuit resistance measurements should be made with ranges other than the 2kΩ range since they cannot turn on silicon junctions and will give more accurate in circuit measurements when active components are present.

2-47. If you are reading resistance and the minus sign remains on, there is still energy in the circuit under test. The circuitry may still have power applied or a capacitor may still be charged. Reversing the test leads will result in erroneous readings. If there is any doubt about the circuit under test, read the resistance, then reverse the test leads. If a minus sign is displayed in either case, the circuit must be de-energized before accurate resistance measurements can be made.

2-48. CONDUCTANCE MEASUREMENTS

2-49. Conductance is the inverse of resistance and can therefore be computed using the formula:

$$S = 1/R.$$

Where: R = Resistance in Ω (ohms)
S = Conductance in S (siemens)

2-50. The three conductance ranges span resistance measurements of 500Ω to 10,000MΩ. These ranges allow noise free measurements of inverse function components (such as photo diodes, high value resistors, diode and capacitor leakage characteristics, or transistor beta). Make conductance measurements as follows:

1. Select the kΩ/S function.
2. Select the desired range by depressing the two appropriate pushbuttons simultaneously.
3. Connect the unknown resistance to the multimeter external input terminals.
4. The unknown resistance should be displayed in terms of siemens.
5. To convert the measurement to ohms, divide the reading into 1.

For example: $\frac{1}{1\mu S} = \frac{1}{1\times10^{-6}S} = 1\times10^{6}$ ohms = 1 MΩ

2-51. Thermometer

2-52. TEMPERATURE DISPLAY

2-53. The thermometer display is a 4-1/2 digit LCD providing 0.1° resolution below 2000°C or °F, and 1° resolution from 2000°C or °F and above. The selected temperature scale (either °C or °F) is indicated to the right of the temperature display. A decimal point, polarity indication, overrange indication, and open circuit indication are also provided.

2-54. OVERRANGE

2-55. Overrange is indicated by either -0.L or 0.L, depending upon input polarity. An overrange display indicates that the unknown temperature input is of an amplitude greater than the selected thermocouple range. It does not necessarily mean that the input will damage the instrument. (Refer to Table 1-1 for overvoltage specifications.)

2-56. OPEN CIRCUIT DETECTION

2-57. A source impedance of 2 kΩ or greater will cause the thermometer to display 0.C. This informs the operator of a faulty thermocouple or poor input connection.

2-58. TEMPERATURE SCALE SELECTION

2-59. The thermometer will display temperature in either degrees Celsius or degrees Fahrenheit. Scale selection is made using the °F/°C switch located to the far left, below the temperature display. Scale changes can be made at any time, and have no effect on the calibration of the instrument.

2-60. THERMOCOUPLE SELECTION

2-61. The measurement range of the thermometer is determined by the type of thermocouple used as the input device. Any one of eight thermocouple ranges may be selected using the rotary SELECT TYPE T/C switch located below the input modules. Refer to Table 1-1 for thermocouple range information.

> NOTE: It is important that the selected range match the type of thermocouple used. Otherwise, all temperature readings will be erroneous.

2-62. THERMOCOUPLE INPUT SELECT

2-63. There are two thermocouple input modules installed in access ports in the thermometer section. The two modules are identical and each provides one set of screw-type input terminals. This allows switch selectable measurement of two temperature sources, by using the two switches located to the right of the input modules.

2-64. Two thermocouple types may also be used. This, however, requires that the operator reselect thermocouple type as well as the thermocouple input module.

> NOTE: The thermocouple input modules have been calibrated to match the specific tester in which they are installed. Measurement errors will result if they are used in another tester without recalibration.

2-65. THERMOCOUPLE SIGNAL SELECT

2-66. Depress the Thermocouple Signal Select pushbutton to enable the CALIBRATION OUTPUT. This connects the output of the internal calibration source to the input terminals of the thermometer. The calibration voltage therefore appears at the screw terminals on the thermocouple input module selected. When measuring temperature, the T/C Signal Select switch should be in the EXTERNAL INPUT (OUT) position. (Refer to a section which follows for detailed instructions on calibrator operation.)

2-67. TEMPERATURE MEASUREMENT

2-68. To make temperature measurements, use the following procedure:

1. Remove one or both of the T/C input modules.
2. Connect the selected thermocouple(s) to the screw terminal(s) on the input modules.
3. Connect the input modules to the mainframe through the access ports.
4. Set the T/C type select switch to match the thermocouple selected.
5. Select the desired temperature scale using the °F/°C select switch.

CAUTION

THE MAXIMUM VOLTAGE THAT MAY BE CONNECTED BETWEEN ANY TWO THERMOCOUPLE INPUT TERMINALS IS 350V DC OR 250V RMS AC. GREATER VOLTAGE MAY RESULT IN DAMAGE TO THE INSTRUMENT.

6. Expose the thermocouple probe to the unknown temperature to be monitored, within the thermocouple's specified range.
7. The probe temperature will be displayed (in °F or °C).

2-69. Thermocouple Calibrator

2-70. The calibrator section provides thermocouple simulation outputs of between -10 mV and +90 mV. It is used for calibration of external thermocouple indicators. Connect and operate the calibrator as follows:

1. Remove one of the T/C input modules.
2. Connect a length of the desired thermocouple wire between the T/C input module and the external indicator to be tested. Observe proper polarity.
3. Install the T/C input module in the FT50010 test set.
4. Select the proper T/C Type on the thermometer.
5. Select the thermocouple input (T/C 1 OR T/C 2) that is connected to the external indicator.

CAUTION

TO PREVENT DAMAGE TO THE INTERNAL CALIBRATOR DO NOT CONNECT HIGH VOLTAGES (GREATER THAN 10 VOLTS) TO ANY OF THE T/C INPUT TERMINALS WHILE THE T/C SIGNAL SELECT PUSHBUTTON IS IN THE CALIBRATION OUTPUT (DEPRESSED) POSITION.

6. Press the T/C SIGNAL select pushbutton to the CALIBRATION OUTPUT (depressed) position.
7. Select the desired temperature scale.
8. Using the COARSE and FINE adjustments in the CAL/OUTPUT section, adjust the calibrator output for the desired temperature display.
9. Adjust the external indicator so that its reading agrees with the FT50010 thermometer display.

2-71. Audio Frequency Counter

2-72. FREQUENCY COUNTER DISPLAY

2-73. The frequency counter display is a 5 digit LCD providing 100,000 counts of resolution. A measurement units indicator (Hz), and overflow indication are also provided.

2-74. OVERFLOW

2-75. A frequency of 100,000 Hz or greater will cause the display to indicate an overflow condition. This display will be five 0's and four decimal points (0.0.0.0.0 Hz).

2-76. COUNTER INPUT SELECT

2-77. There are four interlocked counter input select switches located directly below the counter display. These switches are used to connect the desired frequency source to the input of the frequency counter. The operator can choose between the two internal frequency sources or two external frequency inputs.

2-78. TRIGGER LEVEL

2-79. A one turn pot is provided to allow the trigger level of the selected external frequency input to be adjusted. When the pot is in the full counter clockwise position (MIN) the counter will trigger at any signal greater than 75 mV rms. Turning the pot clockwise increases the trigger level. This allows the user to adjust the trigger level to prevent counting noise on the input signal.

2-80. FREQUENCY MEASUREMENT

2-81. To make frequency measurements, use the following procedure:

CAUTION

INPUT SIGNAL AMPLITUDE SHOULD NOT EXCEED 500V AC PEAK OR 500V DC. ANY AC SIGNALS OF GREATER THAN 100V PEAK SHOULD NOT BE APPLIED FOR LONGER THAN FIVE MINUTES, OR DAMAGE TO THE INSTRUMENT MAY RESULT.

1. Connect the desired frequency source to the frequency counter using the counter input select switches.

2. The unknown frequency will be displayed.

3. The amplitude of the selected frequency source may be measured by selecting the proper multimeter input and range.

2-82. Audio Frequency Sources

NOTE: The following instructions apply to both frequency sources.

2-83. FUNCTION SELECT

2-84. The sine and square wave output functions are selected using a push-push switch located in the upper corners of the audio frequency section.

2-85. FREQUENCY ADJUST

2-86. The output frequency is continuously variable from 25 Hz to 15 kHz. One 10-turn coarse and one 10-turn fine adjustment control are provided for this purpose. Clockwise rotation of either control will increase output frequency.

2-87. AMPLITUDE ADJUST

2-88. A single 10-turn control is used for output amplitude adjustment. Clockwise rotation of the control will increase the output amplitude. Adjustment range is from 0 to 20V rms.

2-89. DC OFFSET

2-90. The output waveform may be superimposed on an adjustable dc offset. The offset is continuously variable between -18V dc and +18V dc.

2-91. The offset control, located directly above the output connector, is a combination push/pull switch and 1-turn potentiometer. Pushing the switch in disables the offset (0V dc offset). When the switch is pulled out, rotating the offset control in a clockwise or counterclockwise direction will make the DC offset more positive or more negative, respectively.

2-92. DC Voltage Sources

NOTE: The following instructions apply to both dc voltage sources.

2-93. RANGE SWITCHES

2-94. Two interlocked pushbutton switches are used to select either of two voltage output ranges. On the lower range, output level is continuously adjustable from 0 to 1V. The upper range provides a maximum output of 10V.

2-95. OUTPUT ADJUSTMENT

2-96. Output level is adjusted using a 10-turn coarse control and a 10-turn fine control. Clockwise rotation of these controls increases output level.

2-97. DC Current Source

2-98. Range switching is provided by two interlocked pushbutton switches. On the lower range, output current is continuously adjustable from about 1 μA to 1 mA. The upper range provides a maximum output of 100 mA.

NOTE: There will be no output current flow unless a load is placed across the output terminals. To obtain a full 100 mA output, load resistance should not exceed 280Ω.

2-99. Output current is adjusted using a 10-turn coarse control and a 10-turn fine control. Clockwise rotation of the controls increases output current.

2-100. Relay Timer

2-101. RELAY TIMER DISPLAY

2-102. The relay timer display is a 4-1/2 digit LCD with 19,999 counts of resolution and decimal point and overflow indication.

2-103. OVERFLOW

2-104. The relay timer is capable of measuring delay times up to 1999.9 seconds (approx 33 min). If that limit is exceeded the display will indicate a timer overflow condition by displaying five "0" and four decimal points (0.0.0.0.0).

2-105. CONNECTOR

2-106. Pins A (+24V) and D (ground 1) are the outputs which supply 24V dc to the relay coil. In Delay PICKUP mode, the timer starts counting when this voltage is applied, energizing the coil. In Delay DROPOUT mode, the timer starts counting when this voltage is removed, de-energizing the coil.

2-107. Pins B (sense line) and C (+24V) are inputs which sense the relay contact closure (for PICKUP) or opening (for DROPOUT).

2-108. TIMER CONTROLS

1. DELAY PICKUP -- (Interlocked with Delay DROPOUT) This mode is for measuring the delay time of a delay pickup relay; that is, the time between the coil being energized and the resulting contact closure. Delay pickup relays are designed with a delay of a few seconds up to minutes.

2. DELAY DROPOUT -- Analogous to delay pickup, this mode is for measuring the delay time of a delay dropout relay; that is, the time between the coil being de-energized and the resulting contact opening.

3. ARM -- The ARM pushbutton is depressed to ready the relay for timing which begins when the START button is depressed. When DELAY PICKUP is selected, no voltage is applied to the relay coil when ARM is selected. However, when DELAY DROPOUT is selected, the coil is energized with +24V (Pins "A" to "D" of the relay timer connector) from the front panel.

4. START -- The START pushbutton starts the timer to count and either energizes the relay coil (in DELAY PICKUP) or de-energizes the relay coil (in DELAY DROPOUT).

2-109. MAKING CONNECTIONS TO THE TIMER

2-110. The relay timer section can be used for both solid state and pneumatic delay relays. All pneumatic types and solid state delay pickup type relays should be connected as shown in Figure 2-1. Solid state delay dropout relays should be connected as shown in Figure 2-2.

CAUTION

THE INSTRUMENT POWER (+24VDC) IS CONNECTED THROUGH THE ARM AND START SWITCHES TO BOTH PIN "A" AND PIN "C" OF THE TIMER CONNECTOR. WHEN MAKING CONNECTIONS TO THE TIMER, BE SURE THAT THE TIMER ARM SWITCH IS IN THE OUT (RESET) POSITION, TO NOT ACCIDENTALLY SHORT THE SUPPLY. ON SERIAL NUMBER 4850001 AND GREATER, AN INTERNAL 1A FAST-BLOW FUSE (F301) HELPS TO PROTECT THE TIMER SECTION.

CAUTION

IF SOLID STATE RELAYS ARE USED, MAKE SURE PIN "A" IS CONNECTED TO THE +24 VOLT SIDE OF THE RELAY/CONTROL INPUT, OR DAMAGE TO THE RELAY MAY RESULT.

2-111. Figure 2-1 shows the relay timer connector located on the front panel, viewed from the front. Pins "A" and "D" of the connector should be connected across the relay coil/or control input. Pins "B" and "C" should be connected across the relay contacts.

2-112. MAKING DELAY PICK-UP MEASUREMENTS

1. Make the timer connections to the relay as in the previous paragraphs and figures.

2. Depress the DELAY PICK UP pushbutton to the IN position.

3. Depress the ARM pushbutton to the IN position.

4. Depress the START pushbutton. The timing operation will now begin and the elapsed time will be displayed. Relay contact closure will cause the timer to halt. The elapsed time will be held in the display.

NOTE: Be sure to record the timing results before switching any of the timer control switches.

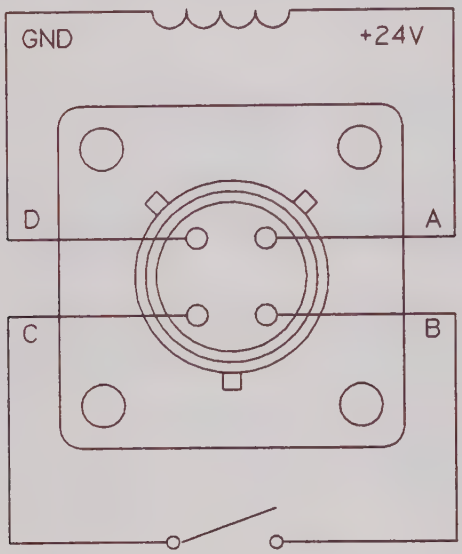

Figure 2-1. Relay timer connections for pneumatic relays (both pickup and dropout), and solid state delay (pickup only) types.

2-113. MAKING DELAY DROPOUT MEASUREMENTS

1. Make the timer connections to the relay as outlined in the previous paragraphs and figures on Making Connections to the Timer.

2. Depress the DELAY DROP OUT pushbutton to the IN position.

3. Depress the ARM pushbutton to the IN position.

4. Depress the START pushbutton. The timing operation will now begin and elapsed time will be displayed. When the relay contacts open, the timer will halt and elapsed time will be held in the display.

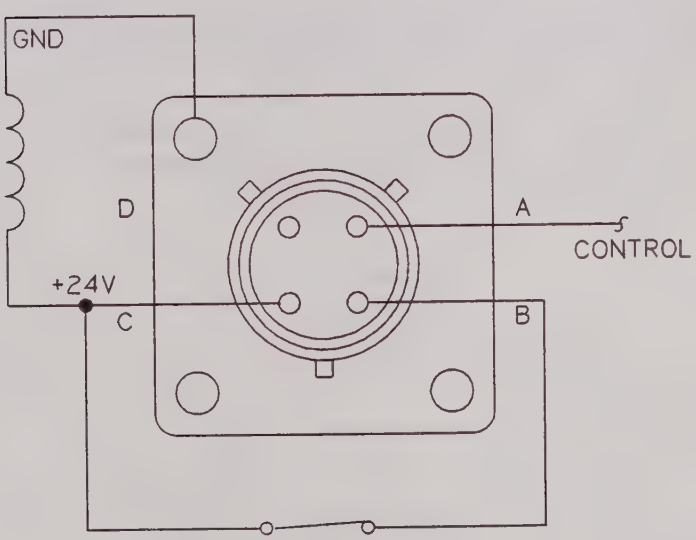

Figure 2-2. Relay timer connections for solid-state delay dropout relays.

2-114. Making Power Input Connections

2-115. Apply power to the FT50010 as follows:

1. Make power connections to the DC source as shown in Figure 2-3. Pin "A" is the DC (+) input, pin "C" is DC (-), and pin "B" is earth ground.

2. Place the power switch to the ON position. The green power indicator adjacent to the power switch should come on. All four displays should also come on.

3. The instrument is now ready for operation.

CAUTION:

TO PREVENT POTENTIAL FIRE HAZARD OR DAMAGE TO THE INSTRUMENT, THE POWER FUSE SHOULD BE REPLACED ONLY WITH A 3A AGC FAST-ACTING 250V FUSE.

2-116. The FT50010 Electrical Systems Test Set is to be operated from a dc power source capable of delivering 20 to 34V at 3A. The power input is protected by a 3A AGC fast-acting 250V fuse located directly above the power input connector.

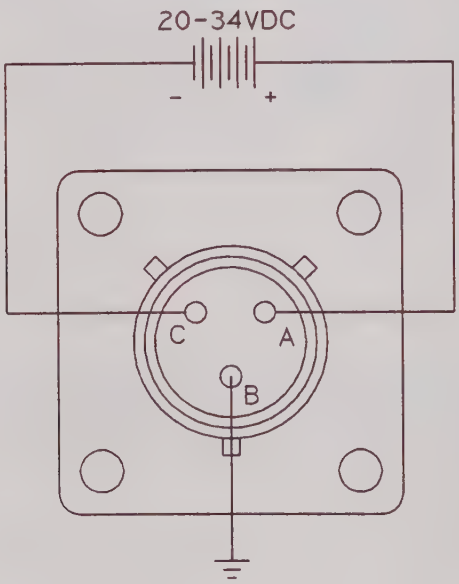

Figure 2-3. Power connections to the FT50010, to the connector labeled "24V 3A MAX".

2-117. FLUKE SERVICE CENTER LOCATIONS

Service of FT50010 units may be performed most readily at the selected Fluke service centers listed below.

AUSTRALIA
Philips Customer Support
Scientific and Industrial
25-27 Paul St. North
North Ryde, N.S.W. 2113
AUSTRALIA
Tel. 61 2 888-8222
Fax. 61 2 888-0440

ENGLAND
Philips Scientific
Test & Measuring Division
Colonial Way
Watford
Hertfordshire WD2 4TT ENGLAND
Tel. 44 923-240511
Fax. 44 923-212157

GERMANY
Philips GmbH
Service VSF
Unternehmensbereich Elektronik
fuer Wissenschaft und Industrie
Oskar-Messter-Strasse 18
D-8045 Ismaning
GERMANY
Tel. 49 89 9605 261
Fax. 49 89 9605 270

JAPAN
Fluke Corporation
Sumitomo Higashi Shinbashi Bldg.
1-1-11 Hamamatsucho
Minato-ku
Tokyo 105 JAPAN
Tel. 03 3434-0181
Fax. 03 3434-0170

NETHERLANDS
Nederlandse Philips Bedrijven B.V.
I&E Division / T&M
PO Box 218
Building TQIII-4
5600 MD Eindhoven NETHERLANDS
Tel. 31-40-788108
Fax. 31-40-786114

SINGAPORE
Rank O'Connor's Singapore PTE Ltd
98 Pasir Panjang Road
Singapore 0511 SINGAPORE
Tel. 65 4737944
Fax. 65 4724508

USA
Fluke Service Center
2104 Hutton Drive Suite 112
Carrollton TX 75006 USA *(Dallas)*
Tel. 214-406-1000
Fax. 214-406-1072